AL-TR-1991-0081

AD-A247 854

ENHANCING THE INTEGRATED MAINTENANCE INFORMATION SYSTEM DIAGNOSTIC MODULE (IMIS-DM): VERSION 5.0

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ARMSTRONG LABORATORY

February 1992

Final Technical Report for Period February 1990 – January 1991

Approved for public release; distribution is unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
February 1992

3. REPORT TYPE AND DATES COVERED
Final – February 1990 – January 1991

4. TITLE AND SUBTITLE
Enhancing the Integrated Maintenance Information System Diagnostic Module (IMIS-DM): Version 5.0

5. FUNDING NUMBERS
C – F33615-88-C-0004
PE – 63106F
PR – 2950
TA – 00
WU – 21

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
Armstrong Laboratory
Human Resources Directorate
Logistics Research Division
Wright-Patterson Air Force Base, OH 45433-6503

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AL-TR-1991-0081

11. SUPPLEMENTARY NOTES

Armstrong Laboratory Technical Monitor: Lt Eric Carlson, (513) 255-6718.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Armstrong Laboratory's Human Resources Directorate (AL/HR) is engaged in the research and development (R&D) of an Integrated Maintenance Information System (IMIS). The system will be capable of accessing and integrating information from several Air Force data bases to provide technical support to the maintenance technician. The support will be provided by a portable computer maintenance aid which will provide instructions for accomplishing maintenance tasks. A diagnostic module will be contained in the portable computer software to help the technician in performing complex diagnostic tasks. This report provides detailed descriptions of the work done to enhance the diagnostic module and develop a system for automatic display of aircraft technical data in preparation for a demonstration on the F/A-18 aircraft.

14. SUBJECT TERMS
Diagnostics
Fault isolation
IMIS
IMIS-DM
Maintenance technician
Troubleshoot
User interface

15. NUMBER OF PAGES
34

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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PREFACE

This report provides detailed descriptions of work done to enhance the Integrated Maintenance Information System Diagnostic Module (IMIS-DM), and develop a system for automatic display of aircraft technical data in preparation for a demonstration on the F/A-18 aircraft. The work was done for the Armstrong Laboratory, Human Resources Directorate (AL/HR), under the terms of contract #F33615-88-C-0004, Task Order #0018. The task manager and principal investigators for the government were Lt. Eric Carlson and Mr. Tim Hansell.

Research was performed by the Dayton regional office of Systems Exploration, Inc. (SEI). Principal investigators were Garth Cooke, Johnnie Jernigan, Nicola Maiorana, Chuck Schmidt, and Mike Costarella.

ENHANCING THE INTEGRATED MAINTENANCE INFORMATION SYSTEM DIAGNOSTIC MODULE (IMIS-DM): VERSION 5.0

SUMMARY

This technical report describes Research and Development (R&D) efforts to enhance certain features of the Integrated Maintenance Information System Diagnostic Module (IMIS-DM) and to develop a presentation system for display of technical data on a portable maintenance aiding system, the Portable Maintenance Aid (PMA). The IMIS is an ongoing R&D effort being conducted by the Armstrong Laboratory Human Resources Directorate (AL/HR) to access and integrate maintenance information from multiple sources and present necessary information to the maintenance technician through a rugged, hand-held computer. The IMIS-DM is the diagnostic module for this system and the PMA is a prototype for the hand-held computer.

There were two major outcomes for this technical effort. Within the diagnostic module capabilities were established to aid the technician in three especially vexing aspects of the diagnostic process which have not been addressed heretofore; namely, Cannibalization, Can Not Duplicate (CND) malfunction, and calculation of an Estimated Time in Commission (ETIC) based upon the actual symptoms present in the system under test. Furthermore, enhancements to the degraded mode facility have been incorporated into the basic functioning of the IMIS-DM module. In addition, a system for display of technical data on the portable computer was developed using the Smalltalk/V programming language. This system was developed to comply with all requirements of the Common User Interface Specification for the F/A-18 Presentation System, a draft specification developed by AL/HR (Ref 3). Both the presentation system and the specification assume the presence of technical order data stored in a format compliant with the Content Data Model (CDM), a type C data specification promulgated by AL/HR (Ref 8).

The capabilities established as a result of these R&D efforts provide a convincing demonstration of the capability to author and present type C data, and a fully rounded capability to assist the maintenance technician in difficult and complex aspects of the day-to-day work.

INTRODUCTION

Purpose

The Armstrong Laboratory Human Resources Directorate (AL/HR) is engaged in a long-term program to improve information presentation in the maintenance environment. Research has led to development of an Integrated Maintenance Information System Diagnostic Module (IMIS-DM) capable of utilizing existing data parameters and producing effective isolation and repair recommendations. Furthermore, a sound and complete Document Type Definition (DTD) for type

C data has been developed. The purpose of the effort described in this report is to enhance certain aspects of the IMIS-DM to provide more complete assistance in three of the more difficult aspects of a diagnostic problem and to develop and to demonstrate the capability to effectively present type C technical data to the maintenance technician using a portable computer referred to as the Portable Maintenance Aid (PMA).

Background

The modern maintenance environment is becoming increasingly inundated with additional computer-based information systems. Examples include the Comprehensive Engine Management System (CEMS), the Core Automated Maintenance System (CAMS), and the Automated Technical Order System (ATOS). Each new maintenance aid forces technicians to learn yet another system. AL/HR is developing the IMIS to facilitate the use of the valuable information these new systems offer, while eliminating the specialization required for each. The IMIS will use a very small, portable computer/display to interface with on-aircraft systems and ground-based computer systems to provide a single, integrated source of the information needed to perform maintenance on the flightline and in the shop. The total IMIS will consist of a workstation for use in the shop, a portable computer for flightline use (the PMA), and an aircraft interface panel for interacting with aircraft systems. The IMIS will access, integrate, and display maintenance information for use by the technician. It will provide the technician direct access to several maintenance information systems and data bases including historical data collection and analysis, supply, technical orders (TOs), and automated training systems. The IMIS will display graphic technical instructions, provide aircraft battle damage assessment aids, analyze in-flight performance and failure data, analyze aircraft historical data, and interrogate on-aircraft built-in-test capabilities. It will also provide the technician with easy, efficient methods to receive work orders, report maintenance actions, order parts from supply, and complete computer-aided training lessons. The PMA will function independently to display all the information the technician needs for on-equipment maintenance. Even if the base-level computer systems are unavailable or the aircraft systems are malfunctioning, the PMA will be able to display TO information and the diagnostic aids to the technician. The PMA will make it possible to present quality information by taking advantage of the computer's ability to interact with and tailor information to technicians of varying levels of expertise.

Based on previous maintenance evaluations and scenarios, the IMIS was divided into four major subsystems: (a) the PMA; (b) an aircraft maintenance panel connected to on-board computers and sensors; (c) a maintenance workstation connected to various ground-based computer systems; and (d) sophisticated integration software that will combine information from multiple sources and present the data in a consistent way to the technician. The technician's primary interface with the IMIS will be the compact, lightweight, battery-powered PMA rugged enough for flightline use. A library of removable memory cartridges will store all TO information and diagnostic aids needed for a single weapon system. The memory cartridges will be designed for fast and easy updating. A digital radio link will be capable of transmitting and receiving both voice inputs and binary data. Advanced digital transmission techniques will allow multiple users on the same frequency, thereby reducing the radiofrequency clutter on the flightline. A high-resolution, flat-panel display will display data clearly under all lighting conditions. The human-computer interface will be designed for ease of operation to eliminate the need for the user to have typing skills. The PMA will have sufficient processing power to quickly display complex graphics and provide rapid responses to the intelligence-based diagnostic aids that will provide advice for difficult fault-isolation problems.

The technician will be able to accomplish most aircraft maintenance tasks without climbing into the cockpit. An aircraft maintenance panel on the outside of the aircraft will provide the interface to on-aircraft systems. The maintenance panel will allow the technician to interact with aircraft systems easily and will reduce the need to climb into the cockpit. This panel will consist of a control and display unit, and an interface connector for the PMA. The aircraft maintenance panel will be used to retrieve data on configuration and subsystem status, interrogate built-in-test and on-board diagnostics, and upload and download mission software. The panel may also be used in conjunction with the portable unit for extended diagnostics and troubleshooting.

The technician will interface with ground-based systems through a maintenance workstation. The desktop workstation will include a full keyboard and an interface computer. The interface computer will have the protocol software required to access the other available data systems. The PMA will connect to the workstation for upload and download of data elements and to preview activities. The workstation will provide the technician with the capability to access and exchange information with systems such as CAMS and ATOS.

The most beneficial feature of the IMIS for the technician will be the integration of information. Instead of dealing with several automated systems and accessing separate groups of information through several devices, the technician will access all information through a single device. At a superficial level, the system will integrate information by employing standard commands and display formats. At a deeper level, through sophisticated software, the system will integrate information from all available sources to provide a coordinated maintenance package.

The IMIS-DM is a software application module in the technician's PMA that helps the maintenance technician to isolate and to repair faulty aircraft components. The IMIS-DM's key features are designed to minimize repair time rather than fault isolation time. This philosophy takes advantage of instances when a rectification would have a higher probability of repairing a problem faster than isolating the problem with tests and then repairing the problem. The IMIS-DM has special subroutines that perform symptom/component matching, taking into account component histories, probabilistic data, logistic constraints, and operational constraints.

IMIS-DM DEVELOPMENTS

Cannibalization/Facilitate Other Maintenance (FOM)

Cannibalization Modeling

Earlier versions of the IMIS-DM could differentiate between feasible options and those that were not due to availability criteria. If the software selected an option that could not be accomplished because of unavailable parts, the option was still displayed, but in reverse video, denoting the parts not available. If the technician selected this option, he received a warning that the needed parts were unavailable but was allowed to proceed without further assistance.[1] The enhancement developed during this effort assists the technician when parts are not available to perform the recommended action. This process can be thought of as cannibalization modeling because the technician who selects actions for which parts are unavailable is probably planning on taking parts from a "good" aircraft to complete the maintenance action. By modeling this process within IMIS-DM, several facets of the maintenance process are expedited: (a) crucial maintenance can be performed to bring a system to operational status even in the case of supply shortages, (e.g., combat); (b) functional testing is facilitated to promote fault isolation; and (c) considerable time is saved.

Cannibalization Process

Cannibalization occurs when the technician removes "good" parts from an aircraft for use in another aircraft under repair. This action can be likened to a swap action, the major difference being that the swapped part is coming from another plane rather than supply. During this swap action, TOs are needed for removal and replacement of parts for the plane being cannibalized as well as the plane under repair. The IMIS-DM will assist the technician in this process by guiding him through the cannibalization, providing appropriate TOs in a logical order, and also allowing him to choose how the cannibalized part is to be used. Two cases are possible. The first case is one where the swapped part is to remain in the aircraft under repair. This case occurs when there is a pressing need to bring the plane under repair to operational status, and disabling another plane is an acceptable consequence. The second case occurs when the swapped part is needed only for troubleshooting purposes. In this case, the swapped part will ultimately be returned to the plane from which it was taken. Each case requires different action by the IMIS-DM.

[1] The individual technician is central to the discussion in this paper. For simplicity, we have used the singular pronoun "he" to designate the individual technician (whether that person is a man or woman).

Cannibalization Dialogue

To incorporate this facility into the IMIS-DM, a dialogue "tree" of possible paths the technician might take during cannibalization was developed and used as the baseline for implementation. This dialogue includes the steps associated with each possible cannibalization case and queries the user as to his intent in order to display the appropriate TOs. The cannibalization routine is initiated when the user selects an option displayed as invalid (the option is invalid because the required parts are not available from supply). When this occurs, the IMIS-DM displays a warning stating the selected option is invalid and asks the user if he wishes to cannibalize another aircraft for the necessary part. After viewing the warning screen, the user may choose to initiate the cannibalization sequence with a YES response, progressing through the shown sequence, or he may avoid cannibalization with a NO response which will proceed with fault isolation as though the part were not available. If the user chooses to cannibalize another aircraft, three sets of TOs are displayed in sequence for removal of the "good" part from the cannibalized aircraft, removal of the "bad" part from the plane under repair, and replacement of the good part in the aircraft under repair. At this time, a functional test is performed to evaluate the impact of the good part. If the functional check fails, further removal and replacement of the good part are suspended until the system checks out. Once the system check is OK, TOs are displayed to return the part to its original location. If the functional test passes, the IMIS-DM prompts the user for his intentions: troubleshooting or to ready an aircraft. Depending on the response, the IMIS-DM displays appropriate TOs to facilitate that choice. When any of these three paths is completed, diagnostics are resumed. If the functional check fails at this point, the technician needs to return to the top of the dialogue "tree." The entire process is shown in Figure 1.

Can Not Duplicate (CND) Failures

A CND problem exists when an operator reports a problem but a fault verification test on the system fails to reveal any problem. This situation can result for any number of reasons, but two diametrically opposed reasons create a diagnostic problem. The problem reported may in fact have been transient and the problem no longer exists in the system. In this case, there is no fault and any maintenance activity to "fix" the problem is probably a wasted effort and may in fact be more likely to introduce errors than to fix them. The opposing problem is that the fault verification test did not span the fault present in the system or the test did not reproduce the environment in which the problem occurred. In this case, a fault does exist in the system, but the technician has no way to observe the effect and begin fault isolation procedures. Previous IMIS-DMs had no convenient method to determine which of these two possibilities exists after a fault verification test passes in all respects.

The revised IMIS-DM provides a method by using an aircraft history file stored in the portable display device and a predetermined CND strategy. The strategy employed is based on the concept of repeat and recurring problems. A repeat problem is one that occurs again on the next flight after it was signed off by maintenance as CND following the previous flight. A recurring problem is one that reoccurs during the second or third flight following the initial report. An occurrence on a fourth or subsequent flight is treated as an independent, unrelated occurrence of the problem.

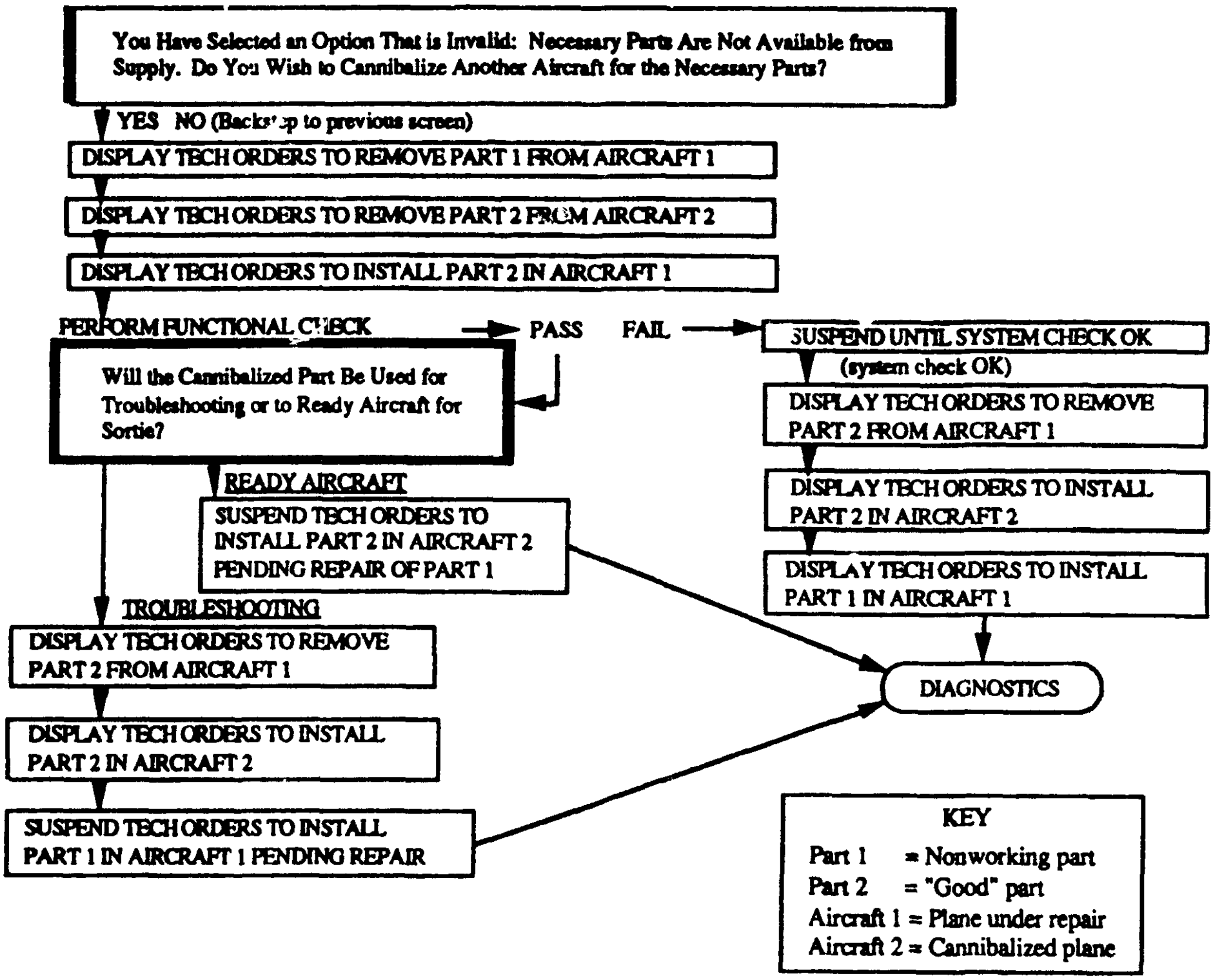


Figure 1. IMIS-DM Cannibalization Dialogue Flow.

The aircraft history file maintained on the portable display device contains recent aircraft flying history (the last four flights), to include (a) date flown, (b) system symptoms, and (c) corrective action taken for any reported symptom. Data in this file are from the Maintenance and Operational Data Access System (MODAS), currently used to obtain operational data. Using this aircraft history file, the IMIS-DM CND handling strategy is:

1. For the initial occurrence of a CND in a system, treat the problem as transient and enter the corrective action as CND.

2. For a repeating or recurring occurrence of the same or a closely related symptom:

a. Search for and perform any tests not included in the fault verification sequence that span the faults implicated by the reported symptom.

b. If no tests are available to do a., perform the action at the top of the Best Actions list.

c. If tests meet the criteria in a., then perform the action at the top of the Best Actions list.

d. If any tests fail, then perform normal diagnostics indicated by those failures for fault isolation and repair.

3. For a third and subsequent occurrence similar to 2 above, perform the second and subsequent recommended actions on the Best Actions list.

Estimated Time In Commission (ETIC) Calculation

The ETIC function provides a calculation of the estimated time a diagnostic exercise will be completed and the weapon system declared operational. ETIC can be calculated several ways. In the manual world of TOs prevalent today, the maintenance technician makes an estimate based on his experience of the time it will take until he completes the first rectification activity he feels is necessary to resolve the reported symptom. This estimate is provided with little more knowledge of the probability of success than: "This sort of worked last time."

In the IMIS-DM, some rudimentary probability calculations are available; hence, we might improve on the current estimating procedure. Two methods of calculating the time are readily apparent. We might choose to perform an exhaustive look-ahead function in which all possible paths to fault isolation and repair are completed. The time to achieve completion of each root node in the tree could be accumulated and the probability of having to proceed to each particular node could be calculated. Given these calculations, ETIC could be presented as a probability table showing the estimated time to achieve some predetermined probability of success (Table 1).

TABLE 1. ESTIMATED TIME IN COMMISSION

Probability	0.25	0.50	0.75	0.95
ETIC	1.0 Hrs.	1.5 Hrs.	2.2 Hrs.	4.8 Hrs.

The second method is to modify the exhaustive look-ahead calculation to account solely for the most probable path to fault isolation and repair. In this methodology, only one path is followed to the root node. That is the path most likely to be chosen at each succeeding node in the tree. The result would be a time and probability to the most likely rectification given the current symptom. This procedure is illustrated in Figure 2.

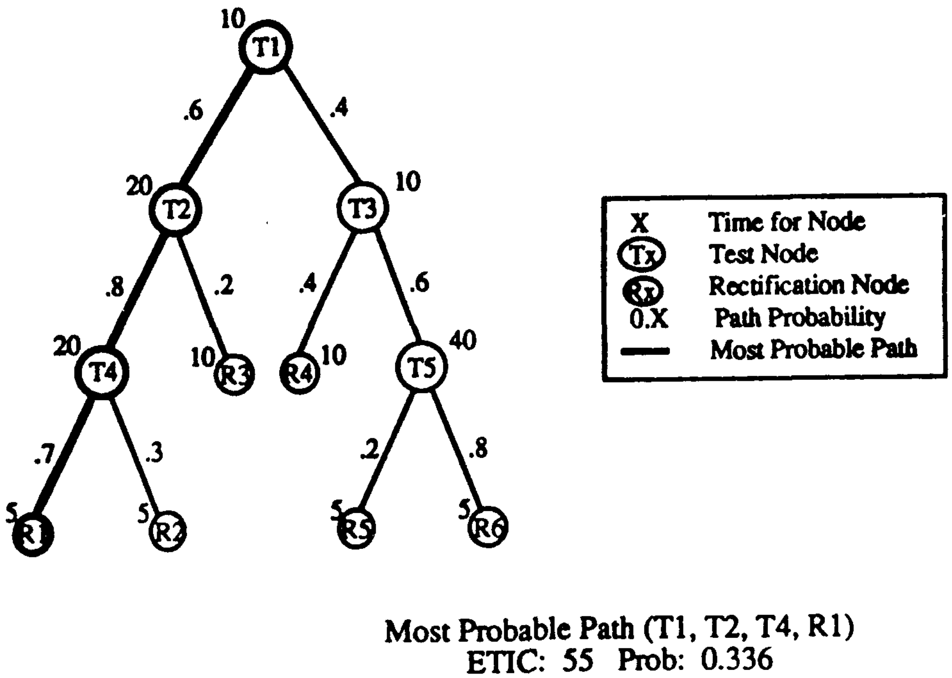
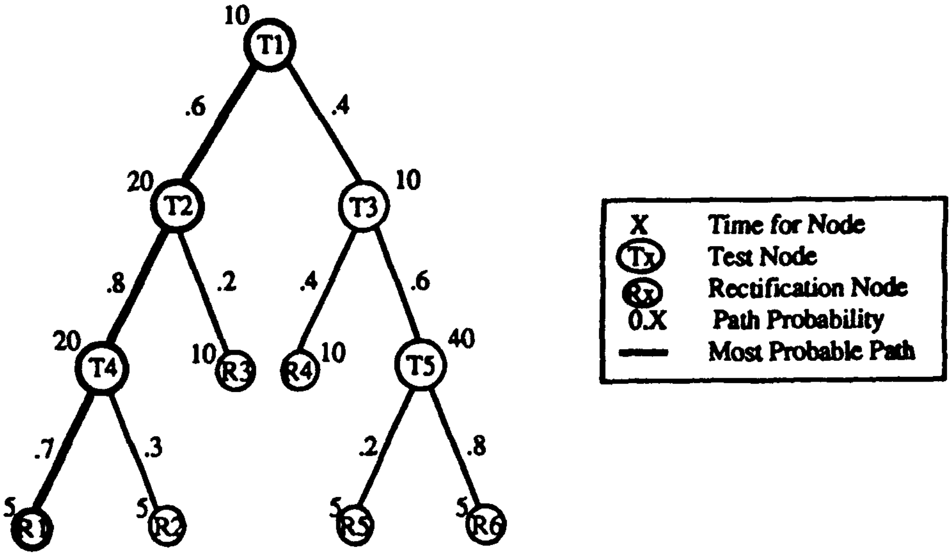


Figure 2. Most Probable Path Calculation.

The method finally selected was a combination of these two methods. The time to completion of the most probable path is calculated along with the probability of following that path, as in the second method. However, rather than stop at that point, other paths through the tree are traced until the cumulative time to proceed further down an alternative path exceeds the time to most probable path completion. For any root node reached prior to exceeding the most probable path time, the probability of reaching that root node is added to the probability associated with the time in commission. In this manner, we achieve a more accurate estimate of the probability the weapon system will be repaired at or before the ETIC established for the most probable path. This process is illustrated in Figure 3. The ETIC can be updated at any point in the diagnostic process by selecting ETIC/New ETIC in the display system.

Working with the AL/HR sponsors of the task and the Human Factors engineers, we developed a display and selection mechanism for the presentation system. At any point during a diagnostic session, the technician can select ETIC from the menu system and obtain either the last computed ETIC along with its associated probability or a new ETIC and probability.



Most Probable Path (T1, T2, T4, R1)
ETIC: 55 Prob: 0.76

	Time	Probability
R1	55	0.336
R2	55	0.144
R3	30	0.12
R4	30	0.16
R5	>55	N/A
R6	>55	N/A

Figure 3. Modified Most Probable Path Calculation.

F/A-18 DEMONSTRATION SYSTEM DEVELOPMENT

F/A-18 IMIS Demonstration System Overview

The second major effort of this task was to enhance the presentation system software initiated under Contract #F33615-88-C-0004, Task 9 in preparation for a Joint Air Force/Navy diagnostic demonstration on an F/A-18 aircraft at Cecil Field Naval Air Station, Florida. The objective of the demonstration is to evaluate technologies under development for the IMIS program. These technologies include the IMIS-DM, the PMA, IMIS presentation system, the content data model (CDM), and the PMA human/computer interface. The demonstration will be accomplished by having technicians perform diagnostics tasks on the F/A-18 aircraft flight controls system using diagnostic and supporting information presented on the PMA. The IMIS-DM will provide the diagnostic strategy required to troubleshoot the system. The performance of the technicians using the PMA and the IMIS-DM diagnostic strategy will be compared with the performance of technicians using the conventional paper technical manuals. For a complete description of the F/A-18 diagnostic demonstration test plan and the IMIS-DM, refer to *Plan for the Navy/Air Force F/A-18 Test of the Interactive Electronic Technical Manual (IETM) at Naval Air Test Center (NATC), Patuxent River, MD* (Post et. al., 1990) and *Integrated Maintenance Information System (IMIS) Diagnostic Module* (Cooke, et. al., 1990) respectively. The IMIS technologies to be tested are described briefly.

Presentation System

The PMA presentation system is a software program written in Smalltalk/V. It provides all of the functionality required for the technician to interact with the PMA and obtain all of the technical data required to perform an assigned maintenance task. The system sequences the technical data, formats it for display, provides an interface to the aircraft Military-Standard 1553 (MIL-STD 1553) data bus, and provides appropriate commands and calls to the IMIS-DM module for dynamic fault isolation and repair. The system also provides a full range of tools and utilities that allow the maintenance technician the capability to complete the assigned job without reference to other job aids, except for large scale, system peculiar test equipment.

In addition to presenting technical data, the presentation system is capable of providing several other types of data which may be required by the maintenance technician. Some of the other data the presentation system is capable of displaying include supply and parts information, aircraft historical data, information on the Navy Visual Information Display System/Maintenance Action Form (VIDS/MAF) for tracking maintenance activities, utilities (e.g., calculator and stopwatch), theory of operation, etc. The ability to integrate and present this information to the technician through a single user interface is one of the prime objectives of the IMIS program that will be demonstrated.

Presentation System Specifications. Guidance for the presentation system software programmers is provided through several specifications. First, the *Common User Interface Specification (CUIS) for the F/A-18 Presentation System* (Eagle Technology, 1991) describes the generic components of the F/A-18 PMA presentation system such as dialog boxes, scrolling, and navigation. Second, the *Technical Information Presentation Specification (TIPS)* (Eagle Technology, 1991) contains the state and transition diagrams constructed to describe in detail the interface of the F/A-18 PMA. The CUIS and the TIPS are meant to be used in conjunction with one another. Third, the Tri-Service IETM specification contains requirements for the content, style, format, and user-interactions require for data to be displayed in electronic format. The CDM is a part of the IETM specification. The IETM specification can be found in *Manuals, Interactive Electronic Technical: General Contents, Style, Format, and User-Interaction Requirements* (Tri-Service IETM Working Group, 1991) and *Data Base, Revisable: Interactive Electronic Technical Manuals, for the Support of* (Tri-Service IETM Working Group, 1991).

The presentation system software is composed of several modules illustrated in Figure 4. All of the software development for the PMA presentation system was accomplished on a Sun-3 workstation designated as the Maintenance Information Workstation (MIW).[2] In addition to serving as a software development tool, the MIW also provided a means of processing data for use on the PMA and a means of loading the data on to the PMA memory modules. Specific details of the software developed for this task can be found in the *Software Design Document for the F/A-18 Demonstration System Development of the Integrated Maintenance Information System (IMIS)* (Kanko et. al., 1990).

Development Language. The PMA presentation system software is written in Smalltalk/V, a high-level object oriented programming environment. There are two reasons why Smalltalk was selected as the development language. The first reason is the rapid prototyping capabilities available through Smalltalk and facilitated through the Smalltalk environment. This environment contains most of the low-level functions used in software development. The environment also allows a programmer to compile and test smaller pieces of code within the environment. Moreover, the Smalltalk environment allows the code to be reused. The second reason for selecting the Smalltalk is the commonality with the IMIS-DM and the authoring system used for data development which are both written in Smalltalk.

PMA

A PMA is a special purpose portable computer being developed for the F/A-18 demonstration project. It is designed to serve as a test device through which the maintenance technician will interface with the technical data and the aircraft. The PMA is a small computer specifically designed to support maintenance on the flightline. It is designed to provide a test vehicle to evaluate technologies such as the IMIS-DM and presentation system, and to provide a means of evaluating the problems involved in using a portable computer on the flightline. Specifications for the PMA are provided in Table 2.

[2]The MIW described in this report is not the same as the one described for the full-up IMIS implementation; but, many of the capabilities available on the F/A-18 MIW would more than likely be a subset of the functions required for the full-up IMIS MIW. A complete description of all the software developed for and in support of the F/A-18 demonstration system can be found in Ref 7.

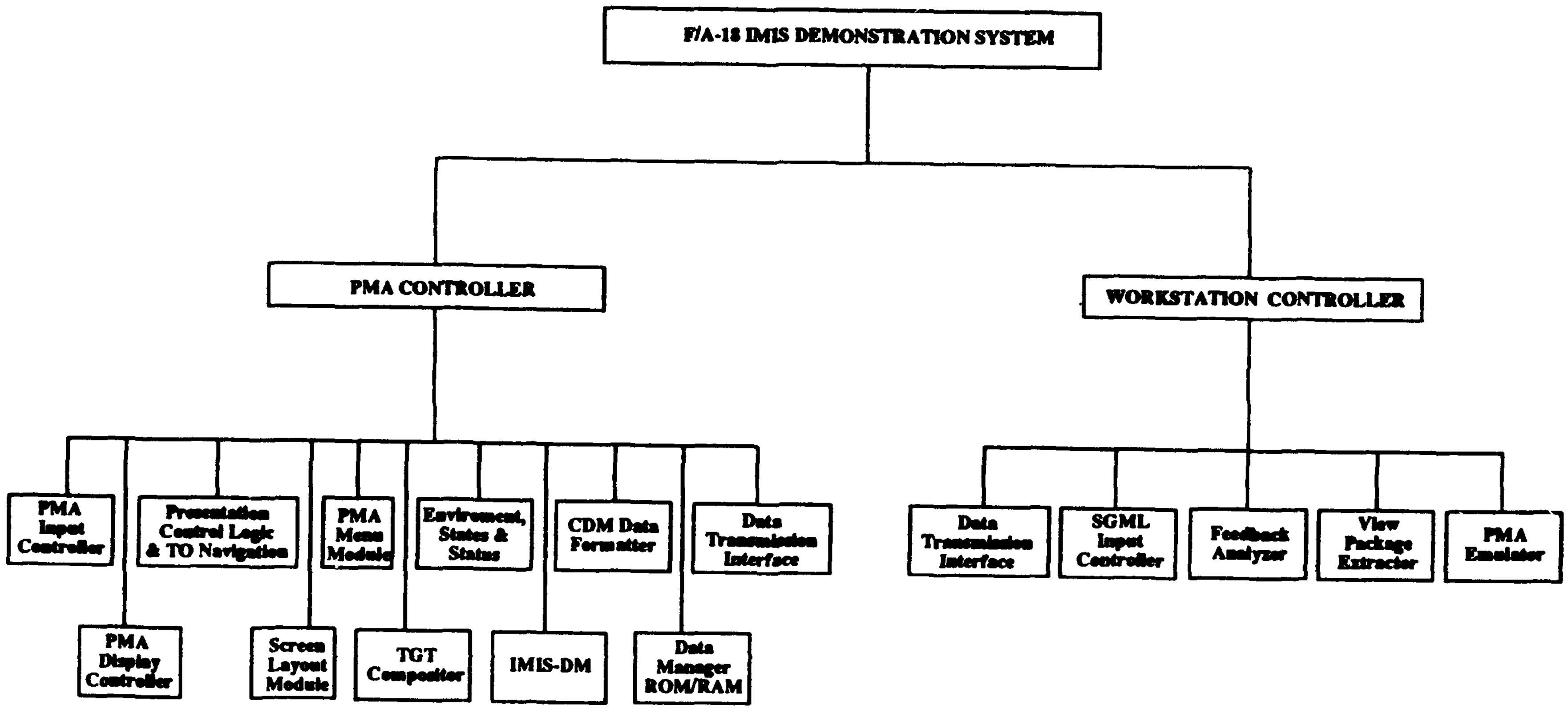


Figure 4. F/A-18 IMIS Demonstration System.

TABLE 2. PMA SPECIFICATIONS

CPU	Motorola 68020-based hybird
Size	9.5" x 10.5" x 2.5"
Case	Carbon-fiber composite
Weight	6 lbs
Display	Ovonics 6" x 8" monochrome active matrix, 640 x 480 resolution
Memory	6 MBtye SRAM, 4 MByte FLASH PROM, 32 MByte removable memory cartidge
Graphics	Intel 87871-based hybrid
Interfaces	MIL-STD 1553, RS 232C, 1.3 MHs channel hopping radio
Power Supply	16.5 Volt Yardney Silvercell battery pack (4 hour), 15 Volt DC external input
Operating System	Application software
Digital Multimeter	AC Volts, DC Volts, Ohms, autoranging

The requirements that the PMA be very small and light weight impose several constraints which impact its functionality and usability. These constraints have forced the development of a unique human/computer interface and place some limits on the information presented (e.g., large graphics). The technician's primary interface with the PMA presentation system software is via a keypad. A full, dedicated alphanumeric keyboard is not available (due to size constraints); therefore, an interface designed to limit alphanumeric entry was implemented. Cursor keys and a mini joystick are provided for cursor movement, in absence of a mouse, touch screen, or light pen. Dedicated function keys are provided for frequently performed functions (e.g., next screen) and programmable function keys are provided for less frequently used functions. Screen size and resolution are at a premium, limiting the usefulness of detailed graphics or large wiring schematics. Efforts to solve these requirements have been implemented in the presentation software and will be evaluated during the demonstration. The PMA screen and keypad interface are depicted in Figure 5.

Content Data Model

The CDM developed by AL/HR is a neutral, data interchange specification for type C data. The type C refers to digital data that contains no formatting information. The CDM identifies the content and interrelationship of organizational level maintenance information documented in a Standard Generalized Markup Language (SGML) DTD. Maintenance information for the F/A-18 demonstration has been authored in compliance with the CDM; this neutral data base of information allows the presentation system software to format the data in a layout optimized for display on the PMA. Using neutral data allows integration and presentation of maintenance information between the PMA, the technician, and the aircraft much more efficient. A more complete description of the CDM can be found in the *Draft Specification for Digital Technical Information* (Gunning and Caporlette, 1989).

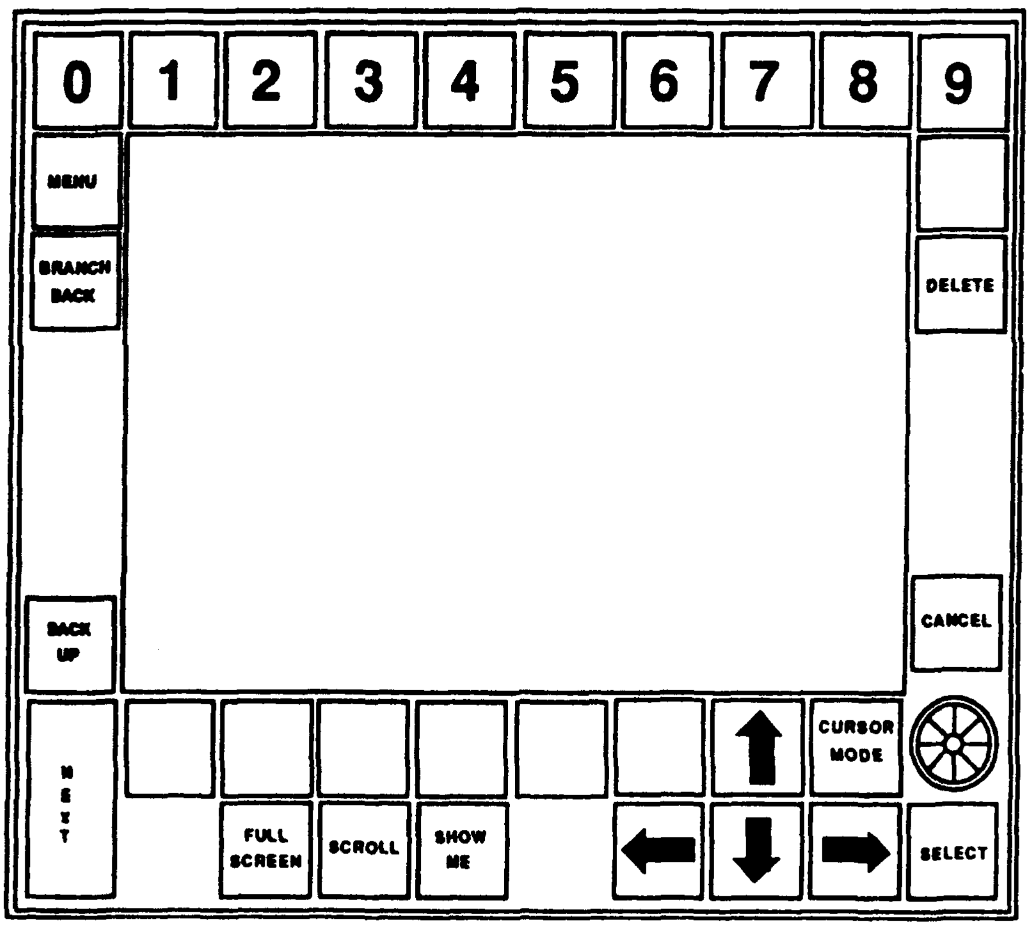


Figure 5. PMA Keyboard Interface.

Maintenance Scenario

The following hypothetical maintenance scenario is presented to illustrate some of the presentation system features and capabilities. Screen descriptions are similar to the ones that will be used during the F/A-18 demonstration and can be found in more detail within the TIPS. Each event (test, step, dialog, etc.) encountered by the technician will produce a new screen state requiring interaction by the technician. Although this abbreviated scenario does not completely describe every screen state the technician may encounter, it does highlight some of the more common screens found throughout a typical maintenance session.

A session is initiated when the technician's man number is entered into the log on screen (Fig. 6).

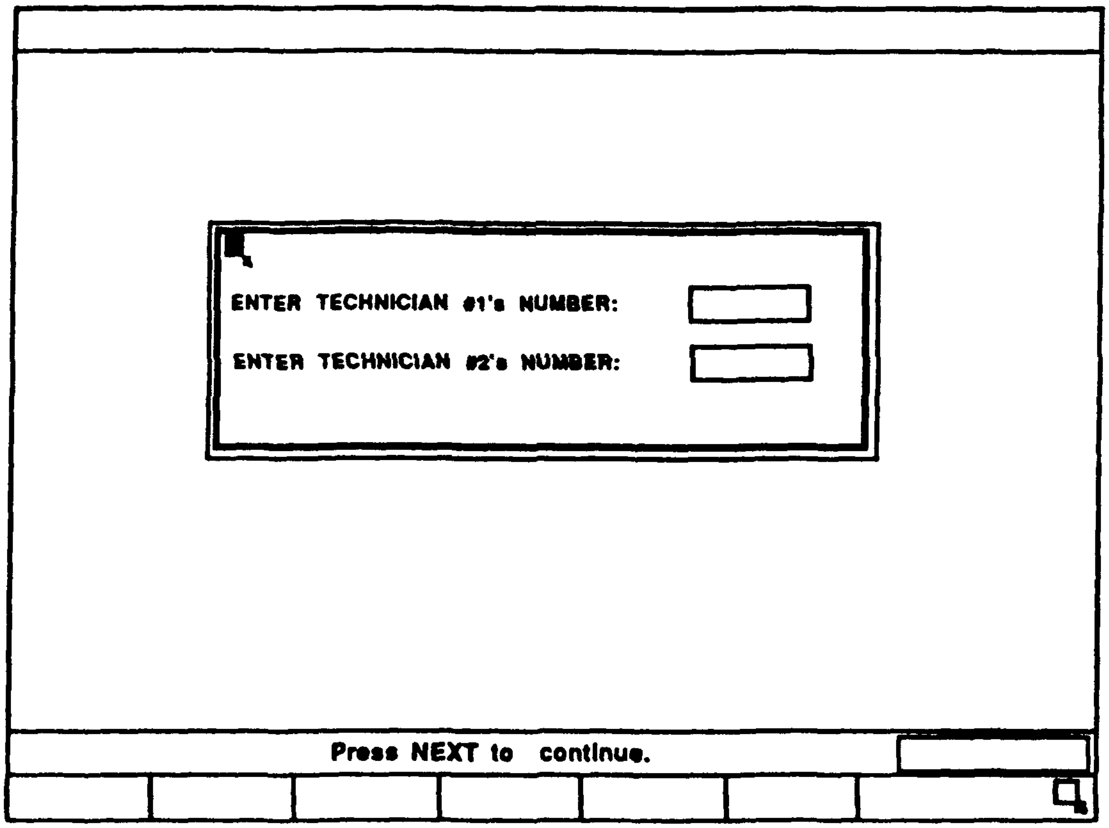


Figure 6. Log On Screen.

After a successful sign on, a representation of the Navy VIDS/MAF form is presented (Fig. 7). This form presents information about the job that the technician needs to get started. The technician can review and enter information required for the form as necessary. The man number, discrepancy, bureau number, date, etc., are included on this form. At the end of the maintenance session, information will be automatically filled in by the software. This information will include maintenance action taken, performance times, how malfunction code, etc.

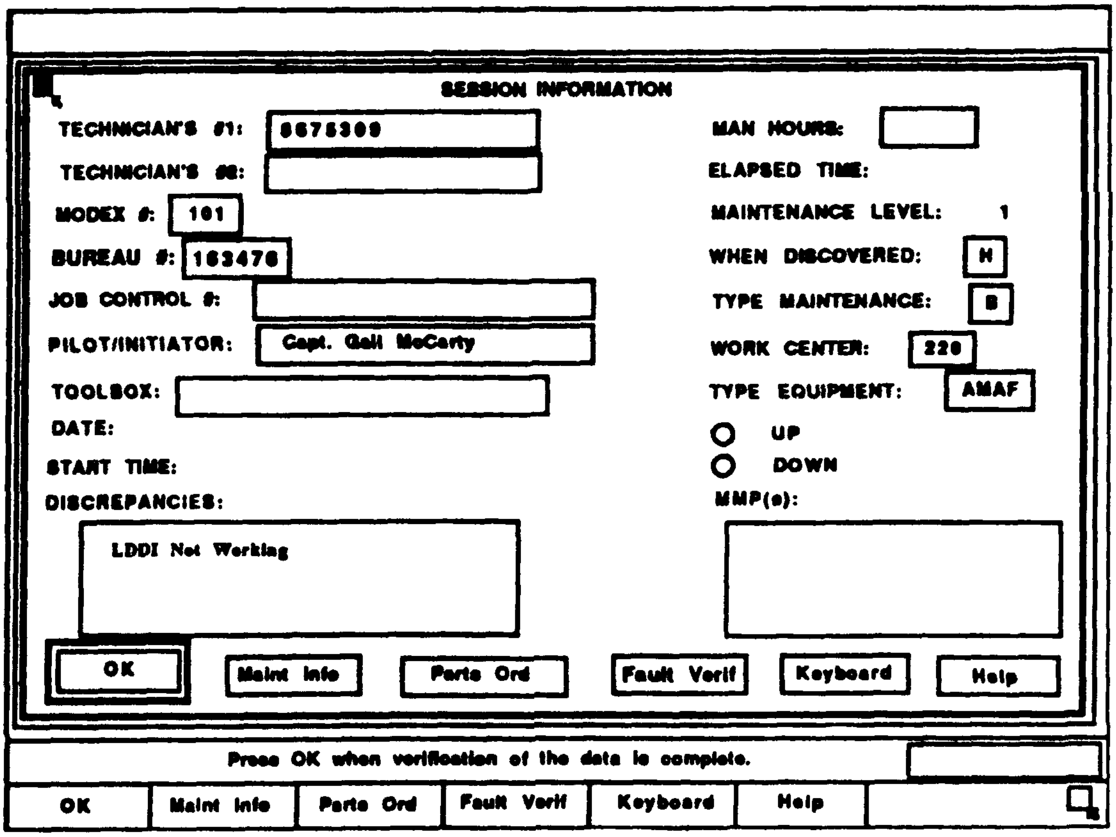


Figure 7. VIDS/MAF Screen.

A normal course of action will have the technician verify the existence of the VIDS/MAF discrepancy on the aircraft before the fault isolation process begins. The technician can access and select a fault verification test from an appropriate list (Fig. 8) through the system-subsystem hierarchy of information. The result of a fault verification test is automatically passed to the IMIS-DM which will analyze the information in order to recommend a course of action.

The first troubleshooting screen presented to the technician will be an IMIS-DM block diagram (Fig. 9). This encoded diagram aids the technician by conveying the following information: the system undergoing troubleshooting; the recommended (or selected) maintenance activity; the suspected component or system (shaded block); the component or system affected by the activity (dark border around block); related systems (ellipse); and any component or system which have been removed from consideration by some previous action (diagonal through block). Soft keys at the bottom of the screen provide access to additional information the technician may wish to see. After every action (test or repair) the block diagram will be updated to reflect the current status of the component or system.

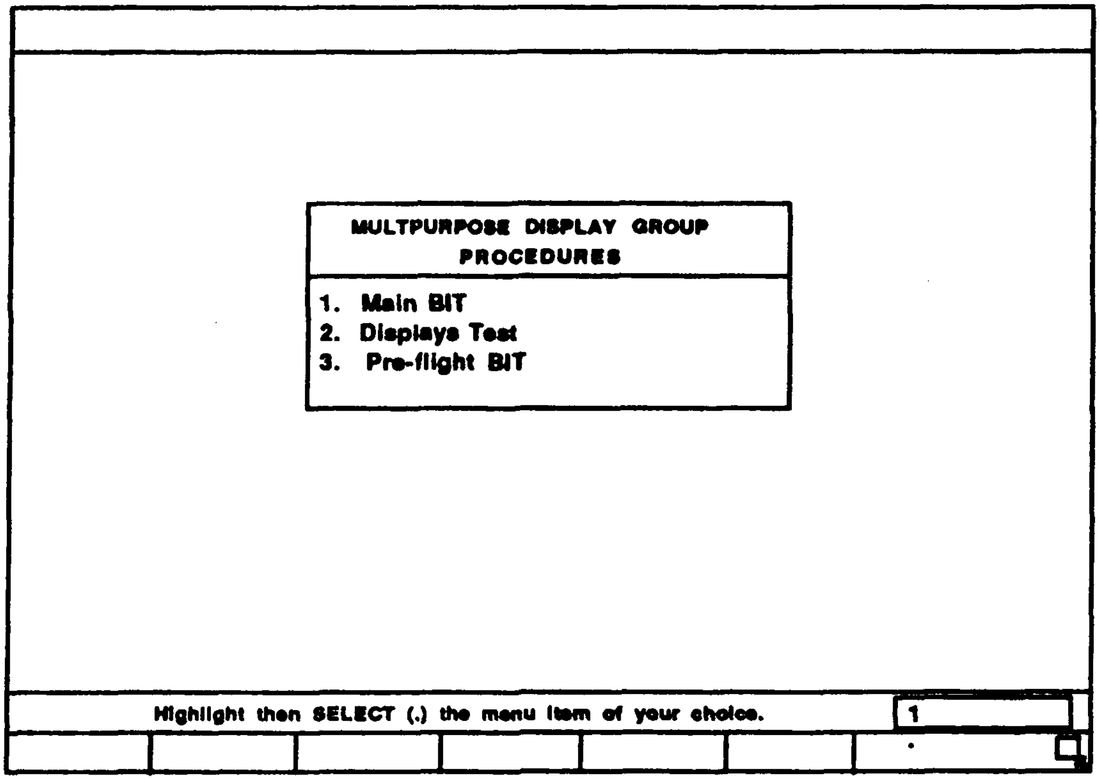


Figure 8. Fault Verification Screen.

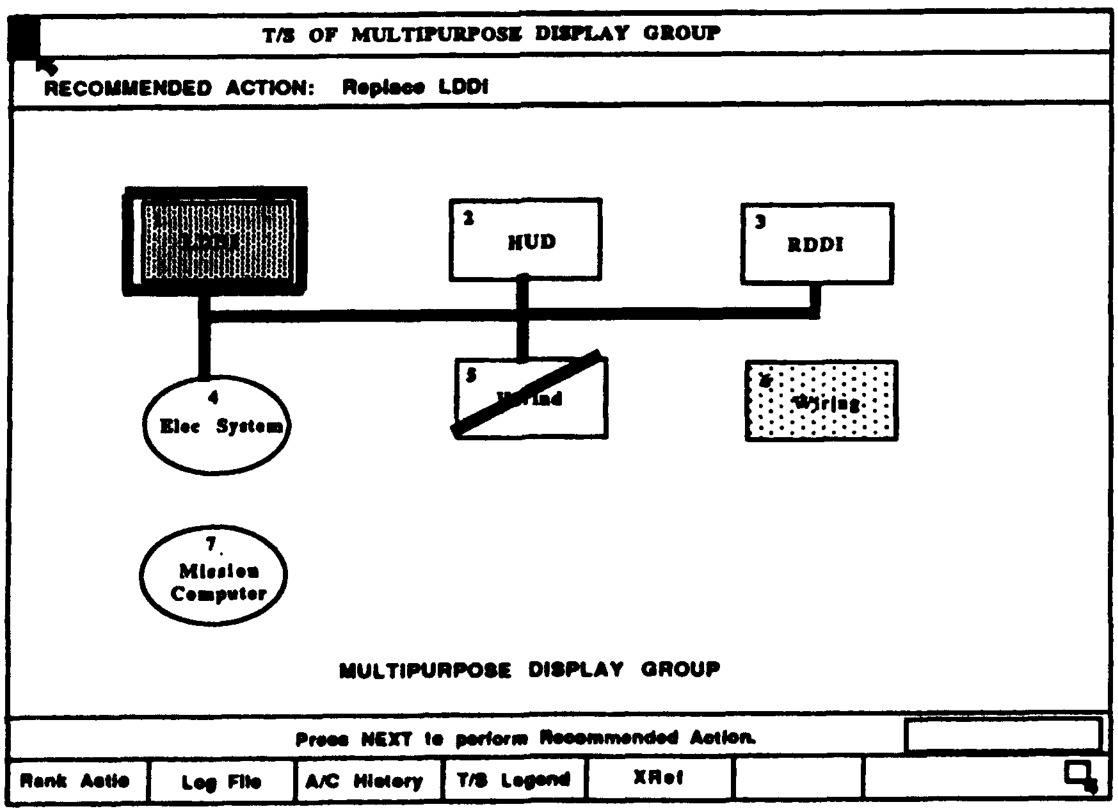


Figure 9. Block Diagram Screen.

After reviewing the block diagram, the technician has the option to perform any available action, not just the one being recommended by the IMIS-DM. Several ranked lists are provided to the technician to aid in the troubleshooting process. One such list, Ranked Actions (Fig. 10), provides an interleaved list of additional actions the technician can perform other than the recommended one. Also included on the list are the time required to perform the action, the failure probability of the action, and the availability of each action. The flexibility built into the system allows the user to take full advantage of their experience and knowledge of the aircraft while still being supported by the IMIS-DM.

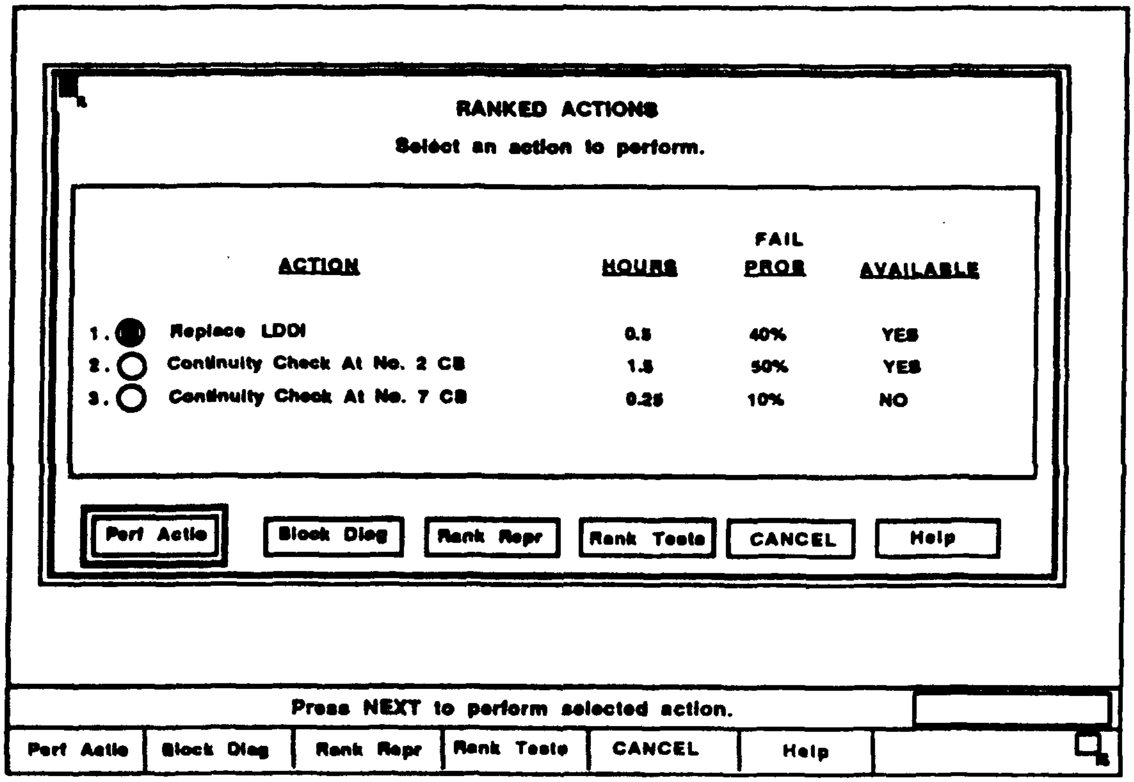


Figure 10. Ranked Actions Screen.

Access to all available information, like the Ranked Actions feature, can be obtained through the menu bar with pull-down and cascading menus. Frequently accessed items are provided as soft keys when appropriate. Figure 11 shows the contents of the Status pull-down menu.

Once an action is selected, procedural information required to perform the task is displayed to the technician. A typical procedural screen may contain text and graphics (Fig. 12). Selectable items are often available on the screen such as callouts or key words so that additional information can be obtained. Most navigation through procedural data is accomplished by striking the NEXT key.

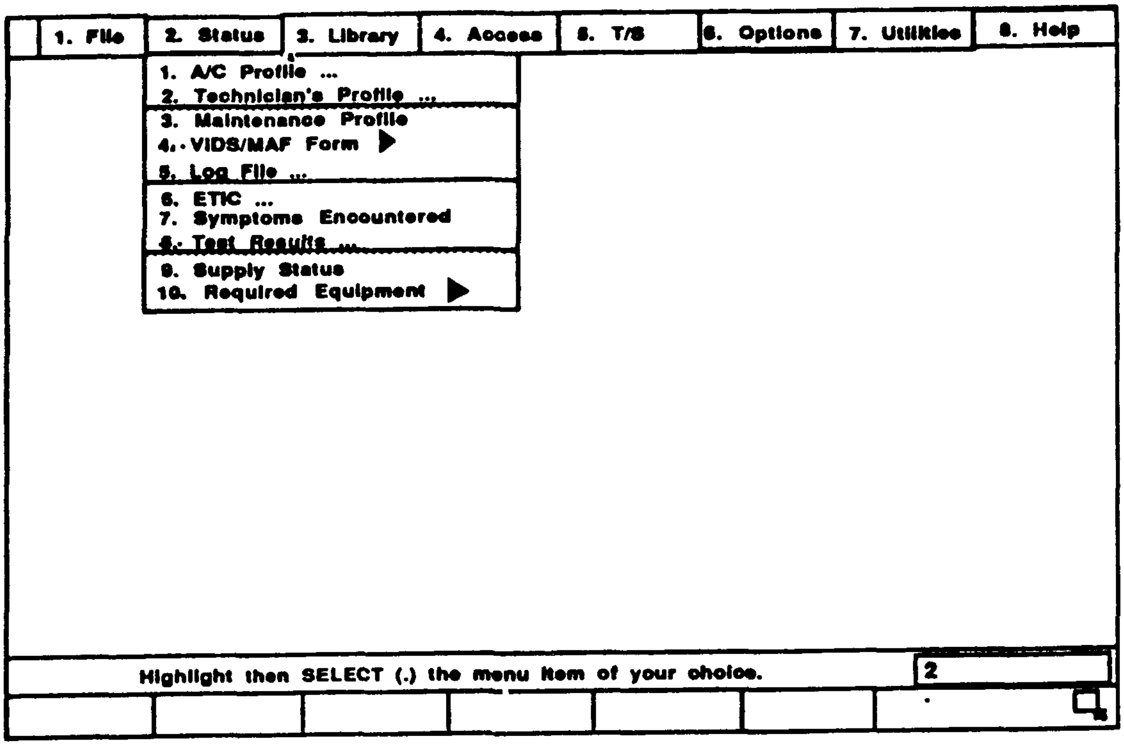


Figure 11. Status Menu Screen.

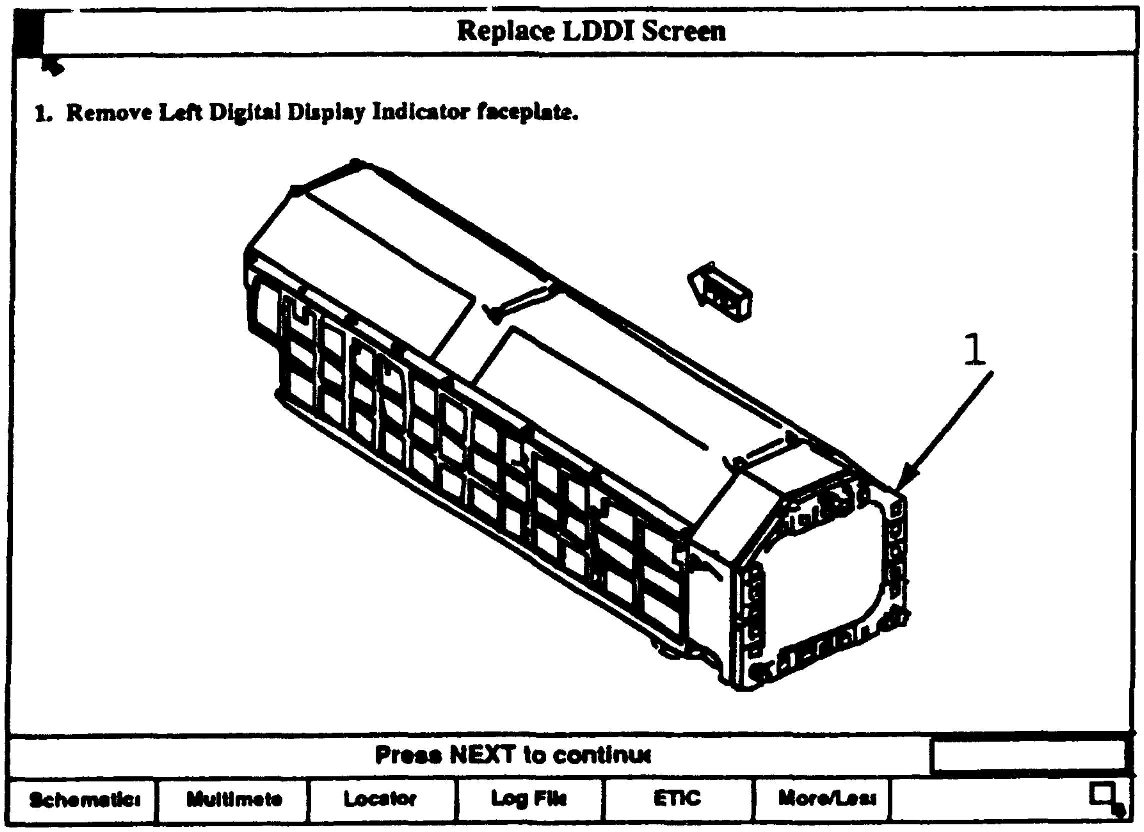


Figure 12. Procedural Screen.

When a Note, Caution, or Warning is required for a task, it will be appropriately displayed before the action and will require the technician's acknowledgment (Fig. 13).

A Log File is maintained during the session (Fig. 14); any time during or after the session, the technician can review the actions they performed and their status.

When the technician has successfully repaired the aircraft, a list of actions required to close out the session is presented to ensure the aircraft is returned to its proper state (Fig. 15).

At the end of a maintenance activity, the technician responds to a prompt to begin a new session or to quit the session (Fig. 16).

CONCLUSIONS

The IMIS-DM has been enhanced by adding components that aid the technician during activities involving cannibalization, troubleshooting CND malfunctions, and estimating ETICs.

The cannibalization enhancement enables the technician to obtain the appropriate technical information and perform maintenance activities on two separate aircraft. This feature is used when the required part is not available from supply and the part is removed from another aircraft either as a temporary installation for testing or as a permanent fix. This enhancement meets a critical need in the maintenance process since cannibalization actions are done to provide high priority fixes when supply shortages or functional testing must be done as fast as possible.

The CND enhancement provides fault isolation aiding when fault verification tests fail to reveal any problem. The enhancement prevents the wasted effort of reaccomplishing tests or replacement actions that have already been done during previous maintenance on the same write-up from a previous flight. The IMIS-DM examines the aircraft history file for the previous four flights and takes into account the indicated faults, previous testing, and completed corrective actions. It then recommends tests that span a different fault set.

The enhancement for the calculation of ETICs replaces the technician's "guess" of how long the aircraft will be out of commission with an estimate based on a logical, mathematical approach. The PMA examines the probable fault set and the associated task times. During the maintenance activity the ETIC can be recomputed on demand and the PMA will take into account the tests and tasks already accomplished.

The F/A-18 demonstration system was developed to provide the required software to present interactive troubleshooting information, maintenance data, and other tools to the flightline technician on a PMA in preparation for a diagnostic field demonstration.

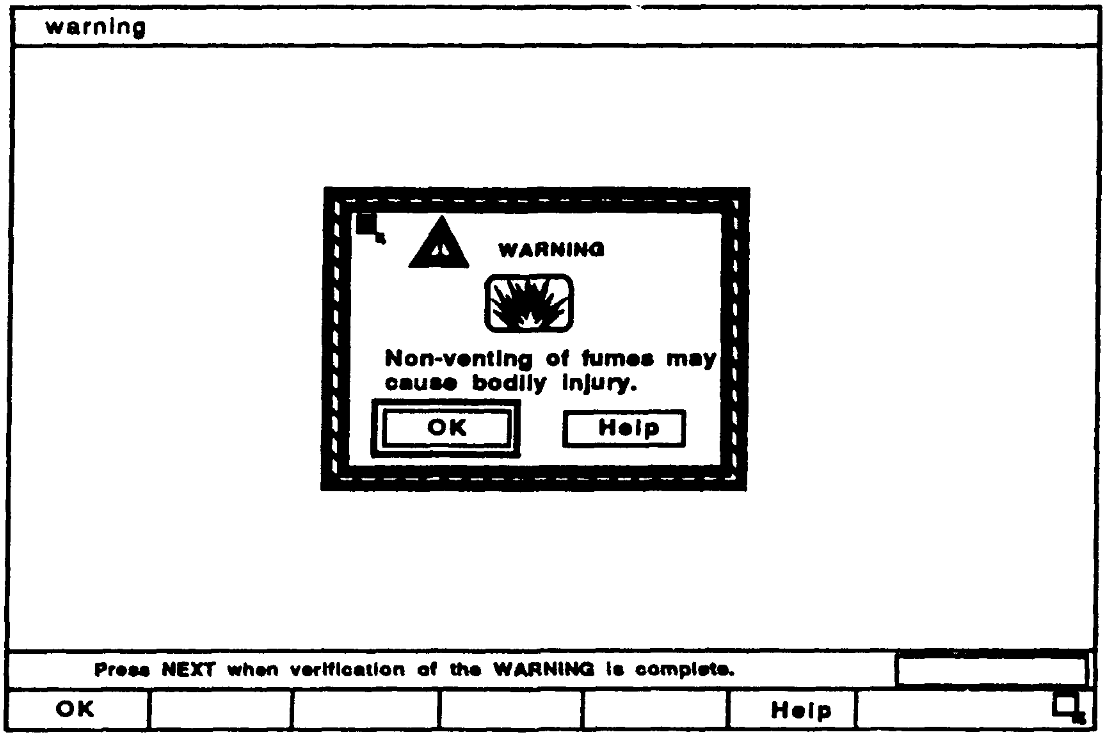


Figure 13. Warning Screen.

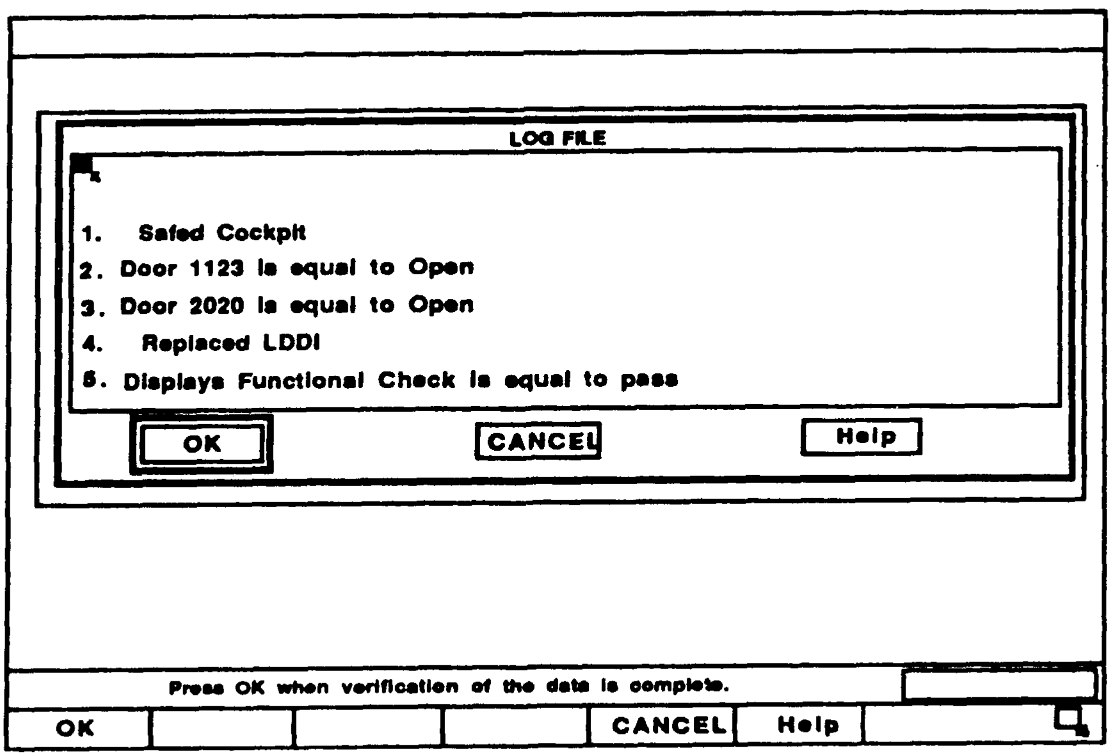


Figure 14. Log File Screen.

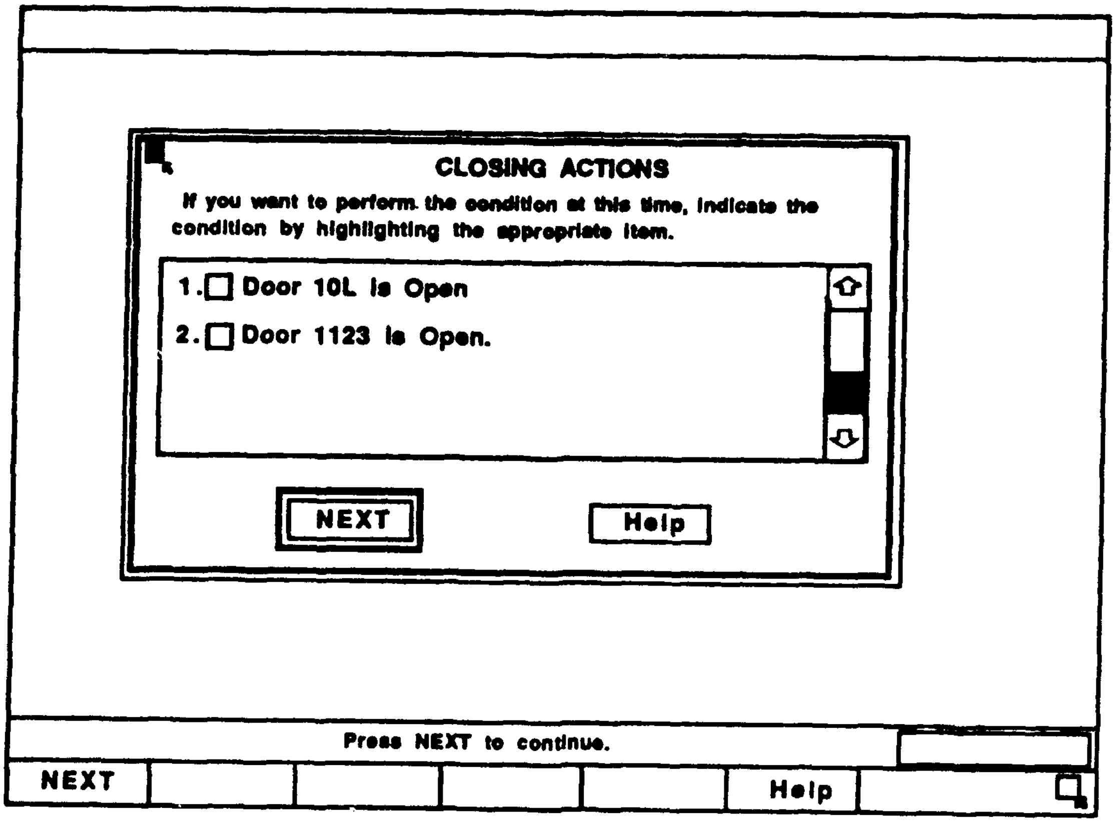


Figure 15. Closing Actions Screen.

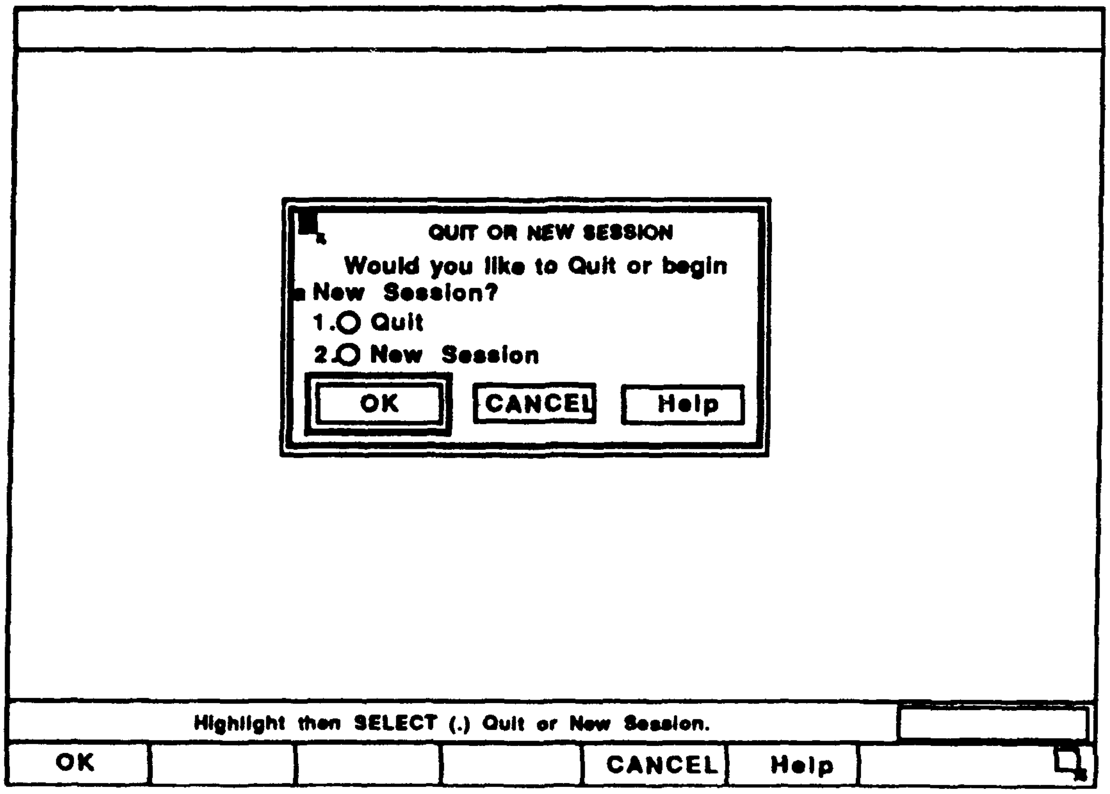


Figure 16. Quit Screen.

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LIST OF ACRONYMS

AFTO	Air Force Technical Order
AL/HR	Armstrong Laboratory/Human Resources Directorate
ATOS	Automatic Technical Order System
CAMS	Core Automated Maintenance System
CDM	Content Data Model
CEMS	Comprehensive Engine Management System
CGM	Computer Graphics Metafile
CND	Can Not Duplicate
CUIS	Common User Interface Specification
DTD	Document Type Definition
ETIC	Estimated Time In Commission
FOM	Facilitate Other Maintenance
IETM	Interactive Electronic Technical Manual
IMIS	Integrated Maintenance Information System
IMIS-DM	Integrated Maintenance Information System Diagnostic Module
MIL-STD	Military Standard
MIW	Maintenance Information Workstation
MODAS	Maintenance Operational Data Access System
PMA	Portable Maintenance Aid
PROM	Programmable Read Only Memory
R&D	Research and Development
RAM	Random Access Memory
SEI	Systems Exploration, Inc.
SGML	Standard Generalized Markup Language
SRAM	Static Random Access Memory
TIPS	Technical Information Presentation Specification
TO	Technical Order
VIDS/MAF	Visual Information Display System/Maintenance Action Form